



MIT International Center for Air Transportation

Operational Aspects of Aircraft-Based On-Demand Mobility

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Joint University Program for Air Transportation

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Princeton University



Aircraft-Based On-Demand Mobility

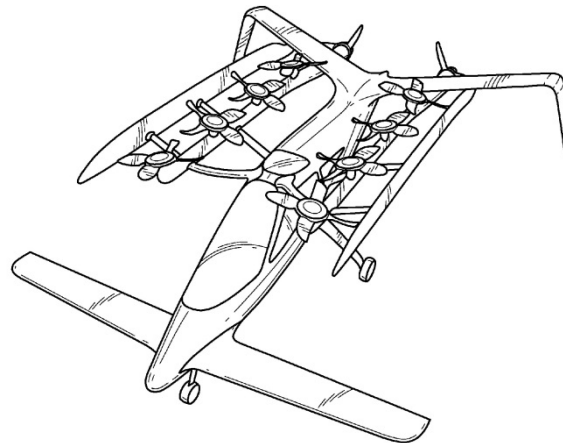
- **Intra-City, Aircraft-Based On-Demand Mobility (ODM)**
 - Multi-modal, point to point transit within a city
 - Enabled by advancements in electric aircraft and autonomy
 - Overcomes highway or transit infrastructure limitations and congestion
 - Expands the mobility reach of economic basins
 - Diversifies mobility options available to residents

- **Key Challenges for Intra-City ODM**
 1. Airspace Integration
 2. Air Traffic Interaction
 3. Ground Infrastructure Availability
 4. Noise Management
 5. Operations and Certification

Aircraft-Based ODM



Joby Aviation



ZeeAero



UberCHOPPER



NASA GL-10



Carter Aviation Technologies

Are proposed CONOPS for On-Demand Mobility consistent with airspace integration, regulation, and operational constraints, both today and in the future?



MIT ODM CONOPS Study

- **MIT Study on ODM Airspace Operations and Integration**
 - Began collaboration in February, 2016
 - Goal is to determine the range of reasonable concept of operations (CONOPS) for intra-metropolitan air transportation
 - Consider airspace, regulatory and infrastructure constraints
 - Collect extensive stakeholder and subject matter expert input
 - Focus on Los Angeles county as preliminary case study

Phase 1: Short-Term Implementation

- Operation within existing airspace definitions, regulations and constraints
- Human piloted 1-2 passenger personal air vehicles and 2-4 passenger ODM vehicles

Phase 2: Longer-Term Architecting

- Investigate airspace, regulation or constraint changes to enhance ODM operations
- Additionally consider package delivery UAS, automated manned vehicles and 4-9 passenger thin-haul aircraft



Business Concepts

- **Private Air Transportation – Part 91**
 - Privately owned aircraft
 - Jointly owned aircraft
 - Rented or leased aircraft
- **Personal Scheduled Transportation – Part 135**
 - Commercial fractional ownership/carded aircraft
 - Commercial chartered aircraft
- **Personal Unscheduled Transportation (ODM) – Part 135**
 - Commercial air taxi
 - Privately owned, commercially coordinated air taxi
- **Commercial Scheduled Transportation – Part 121**
 - Regional Airlines
 - Trunk Airlines



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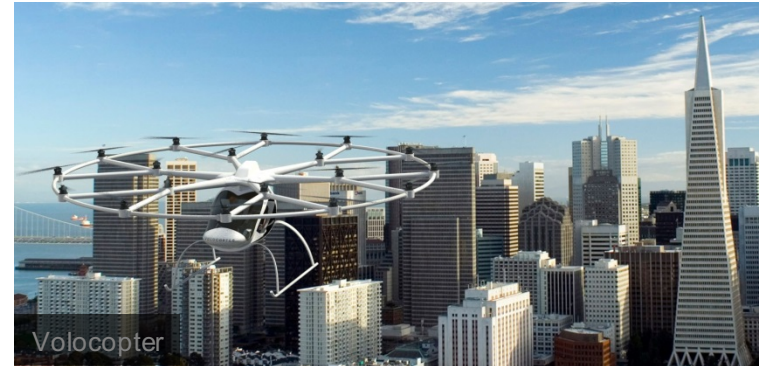
“Thin-Haul” vs “Intra-City” ODM

Thin-Haul Commuter



- 4-9 passengers
- fixed wing configuration
- standard runway or STOL
- distributed electric or hybrid/electric propulsion
- 200 – 300 knot cruise
- mission range 150 – 300 miles

Intra-City ODM



- 1-4 passengers
- tiltrotor or rotorcraft config.
- VTOL
- quiet electric or hybrid/electric propulsion
- mission range 5 - 50 miles
- Enhanced autonomy

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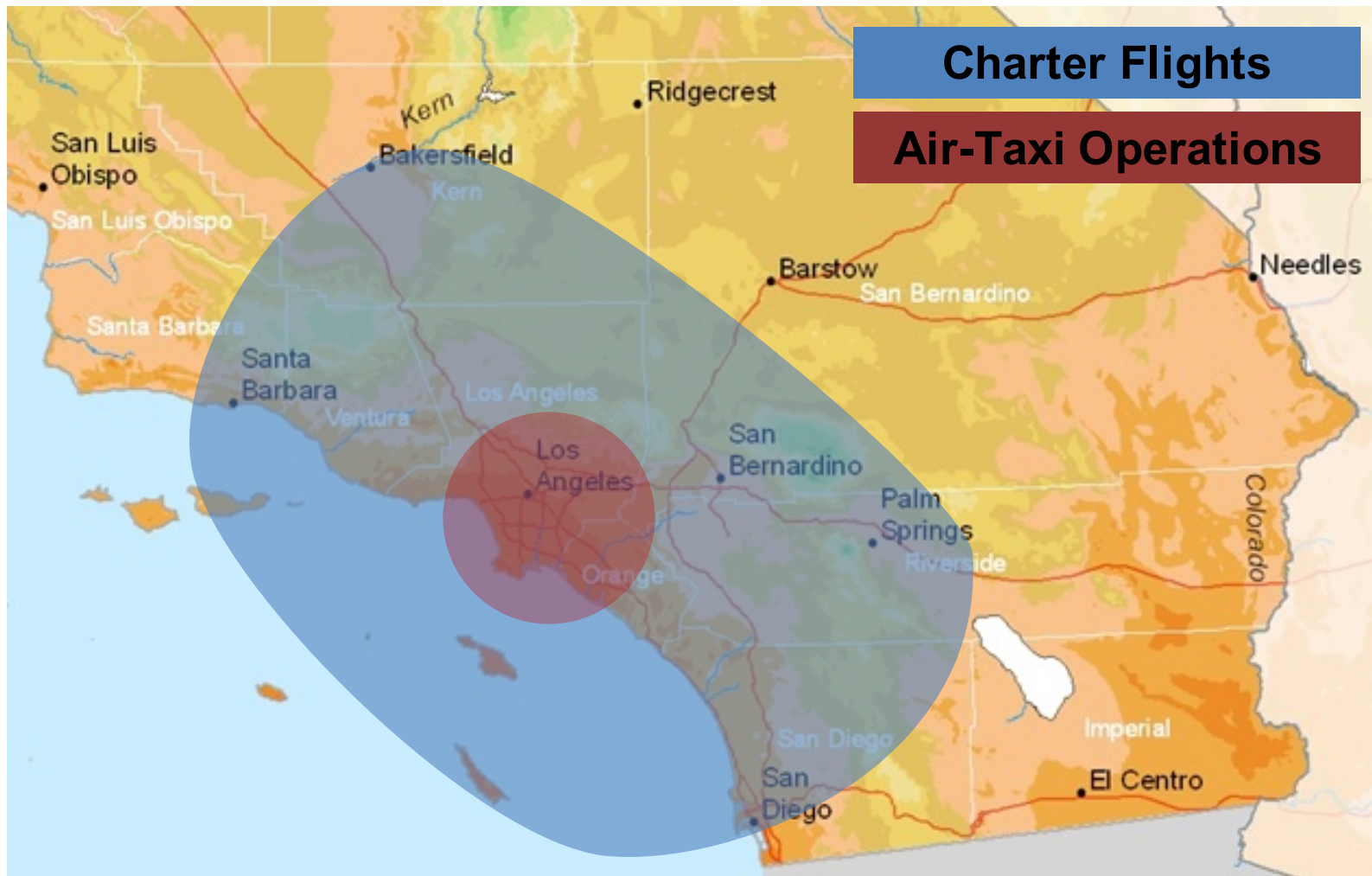
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Case Study Overview

- **Focus on Los Angeles as a pathfinder market due to unique infrastructure availability and favorable weather conditions**
- **Case study will follow seven steps**
 1. ODM boundary definition
 2. Consumer demand estimation
 3. Reference mission definition
 4. Constraint analysis
 5. Near-term CONOPS definition
 6. Constraint sensitivity analysis
 7. Long-term CONOPS definition
- **Lessons from the case study will be applied to define “ODM leading indicators” to allow for a rapid identification of global cities that are well suited to ODM adoption**



LA Case Study Boundary





LA Consumer Demand Estimation

Four categories of potential mission operations were defined:

1. Daily Commute: Aircraft is utilized during business days to transport individuals between a location near their place of residence to a location near their place of work, and vice-versa
2. Weekly Commute: Aircraft is utilized to transport individuals to and from their place of residence and place of work on a weekly basis
3. Non-Commute Point to Point: Aircraft is utilized to transport an individual (or goods) on a non-commuter trip between two locations
4. Non-Transportation Mission: Aircraft is operated to provide a non-transportation value. This may include sightseeing, law enforcement, or news gathering, for example



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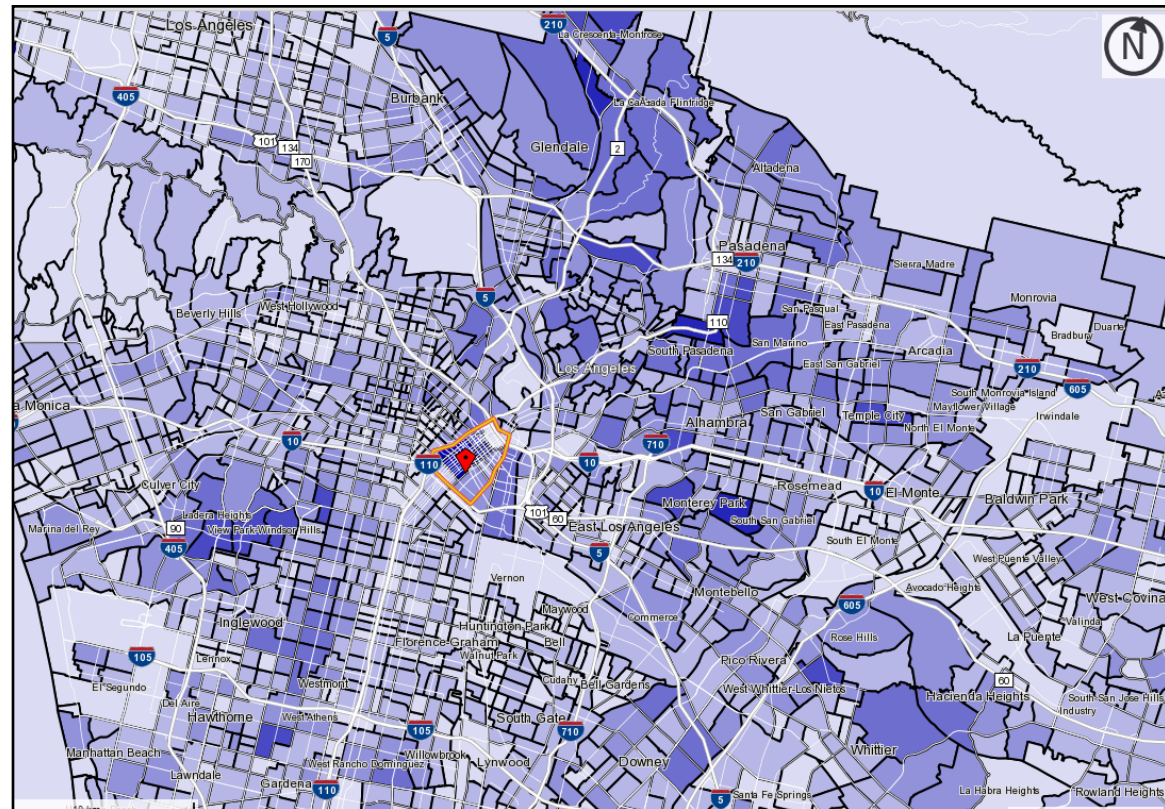
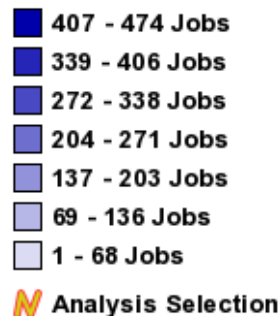


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- Southern California**
Popular Charter Destinations
- Las Vegas
Laughlin
Lake Havasu
Barstow
Kern
Bakersfield
San Luis Obispo
Santa Barbara
Malibu
Family Wines
California Motor Speedway
Palm Springs
Coachella Valley Music and Arts Festival
Stagecoach Country Music Festival
Thornton Winery
Temecula
Carlsbad
San Diego
El Centro
- STAR HELICOPTERS**
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88-TO-FLY-STAR
- 0 15 30 60 Miles
0 25 50 100 Kilometers

LA Consumer Demand Estimation

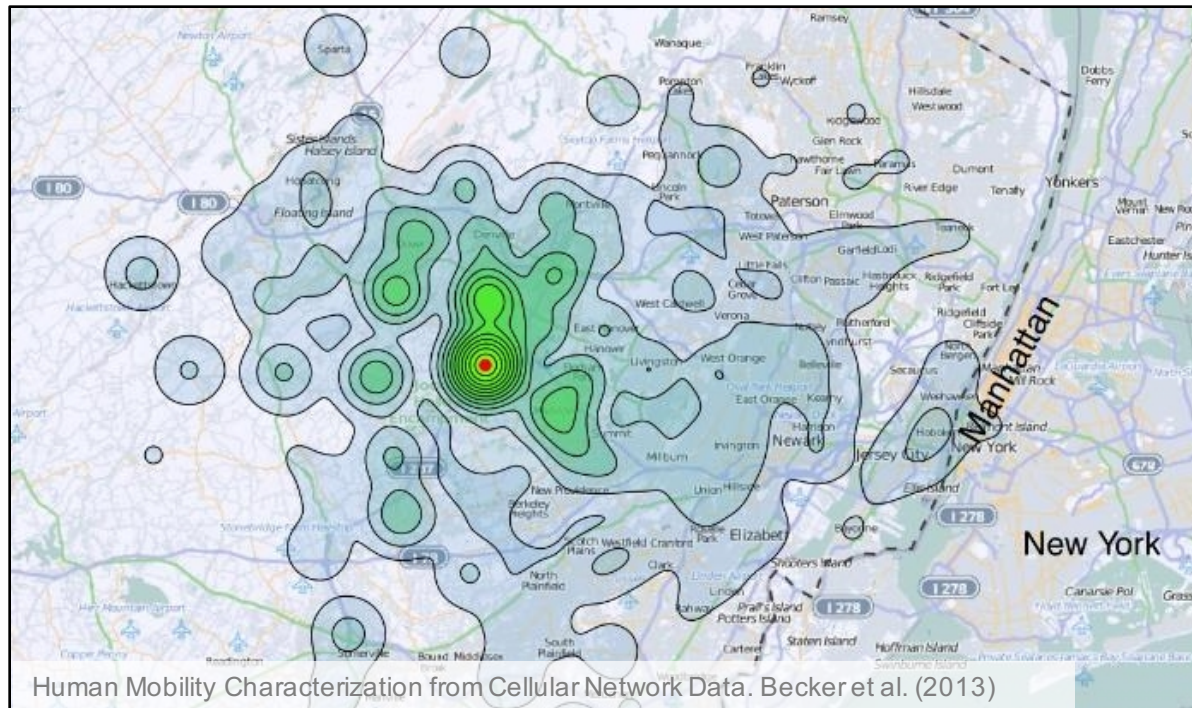
- Consumer demand for these two mission categories was estimated through three primary mechanisms
 1. Review of current air taxi and charter services
 2. Analysis of census data

3006 (Los Angeles, CA)	2014
Total	
All Workers	344
Worker Age	
Age 29 or younger	24
Age 30 to 54	218
Age 55 or older	102
Earnings	
\$1,250 per month or less	28
\$1,251 to \$3,333 per month	67
More than \$3,333 per month	249



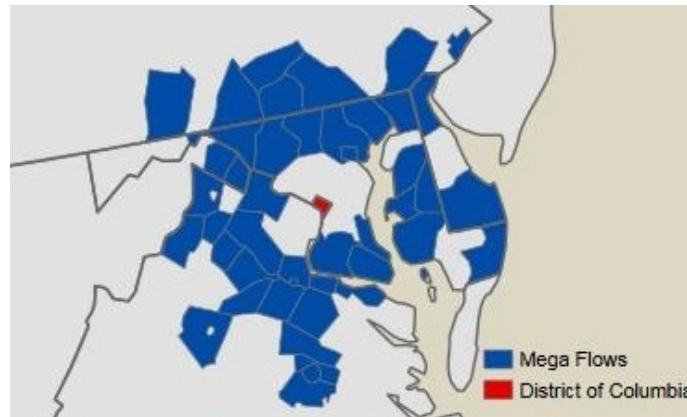
LA Consumer Demand Estimation

- **Consumer demand for these two mission categories was estimated through three primary mechanisms**
 1. Review of current air taxi and charter services
 2. Analysis of census data
 3. Analysis of cell phone tracking data



LA Reference Missions

- The consumer demand data was utilized to define a set of reference missions for each mission category
- The daily commuter reference missions generally captured transportation to and from:
 - “extreme commuting” neighborhoods with travel times of 90 minutes or more, each way
 - “isolated” neighborhoods with natural ground transportation barriers (such as bodies of water) in the line of travel
 - “high income” neighborhoods who may be early adopters

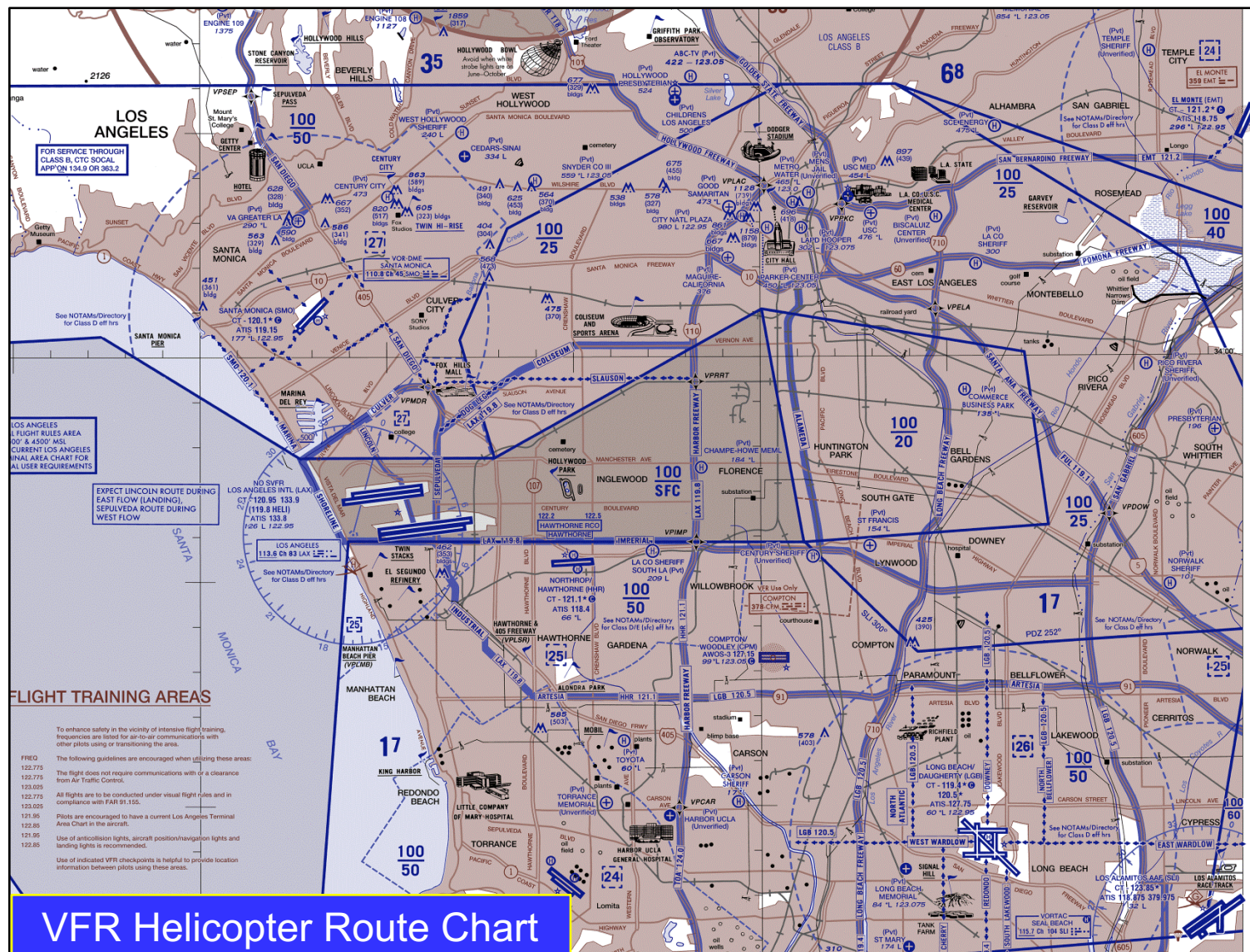




LA Reference Missions

- **The consumer demand data was utilized to define a set of reference missions for each mission category**
- **The point to point reference missions characterized current air taxi missions and potential early adopter markets including flights to:**
 - Sporting events or performances (*i.e. Dodgers stadium*)
 - Central business districts (*i.e. city centers*)
 - University and other technology campuses (*i.e. JPL, McDonnell Douglas, Google, etc.*)
 - Recreation or tourist sites (*i.e. beaches, shopping, country clubs, casinos, theme parks, vineyards, etc.*)
 - Transportation nodes (*airports, train stations, bus stations*)
 - Healthcare facilities

LA Basin Airspace Constraints

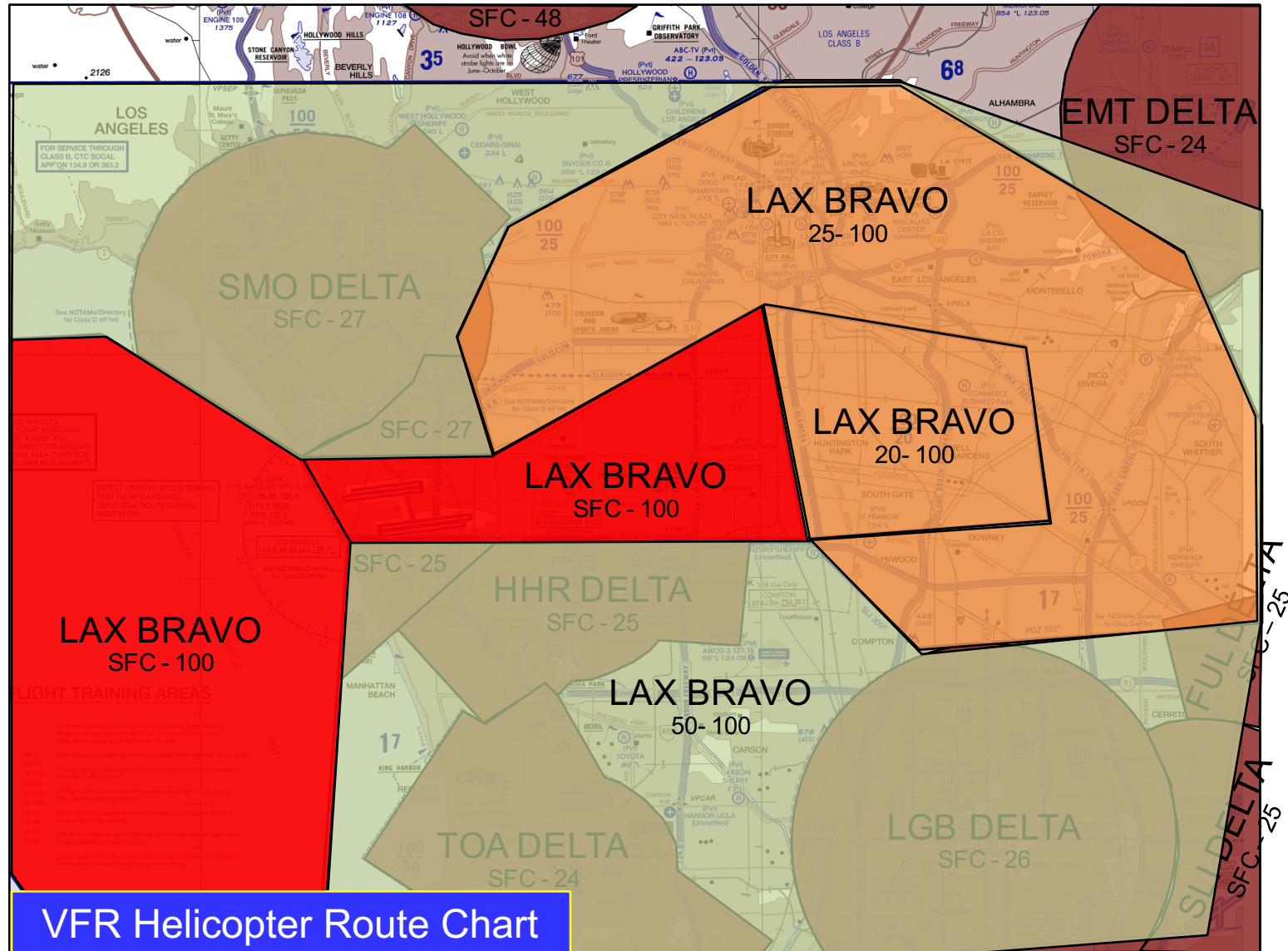




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LA Basin Airspace Constraints

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Existing LA Ground Infrastructure Constraints

- **Existing LA ODM Aircraft Ground Infrastructure**
 - 15 public use airports
 - 11 private use airports
 - 138 private use FAA registered heliports
 - A large number of Emergency Helicopter Landing Facilities (EHLF) on high-rise buildings



Century City



Los Angeles Times



Cedars Sinai
(EHLF)



Existing LA Ground Infrastructure Constraints

- **Los Angeles Municipal Code 57.4705.4**
 - All buildings over 75 ft constructed since 1974 in LA County must have an Emergency Helicopter Landing Facility (EHLF) or heliport
 - Dimensions of pad must be at least 50 x 50 ft
 - EHLF facilities are not certified by the FAA for commercial use
 - LA Fire Policy 10 released buildings from this requirement beginning in 2014



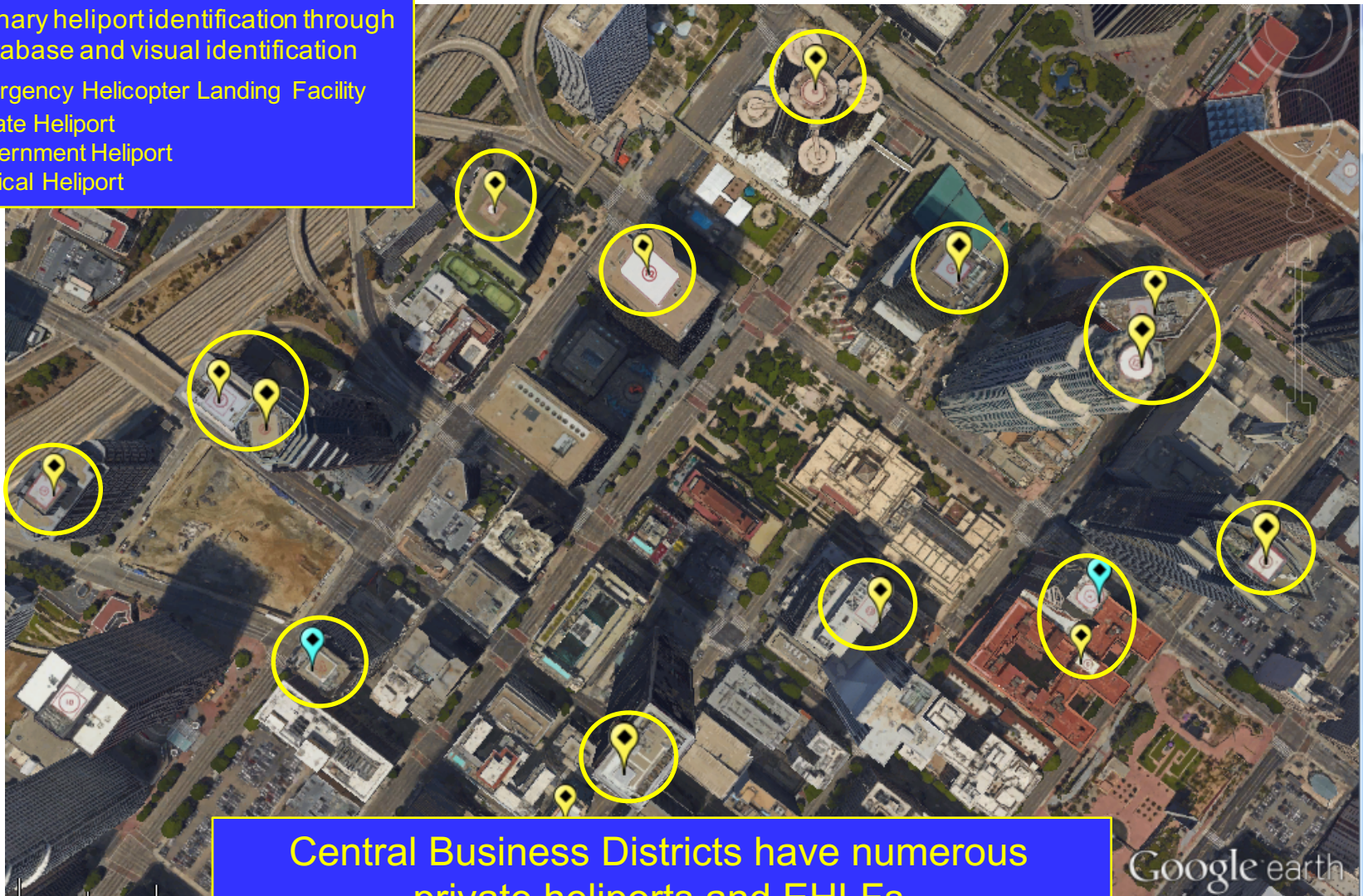
Existing LA Ground Infrastructure Constraints

- **While helipads are numerous in LA, their utilization for ODM operations faces numerous challenges**
 - Uneven distribution and the existence of unserved areas
 - No public heliport facilities
 - Certification and transition of emergency landing pads to usable commercial facilities
 - Airport facilities are limited and possess little ability to expand to accommodate high volume ODM operations
- **The development of new facilities or the use of alternative landing locations may be investigated subject to:**
 - Heliport design: AC 150/5390-2
 - Vertiport design: AC 150/5390-3 (cancelled 2010)

Existing LA Ground Infrastructure Constraints

Preliminary heliport identification through HAI database and visual identification

-  Emergency Helicopter Landing Facility
-  Private Heliport
-  Government Heliport
-  Medical Heliport

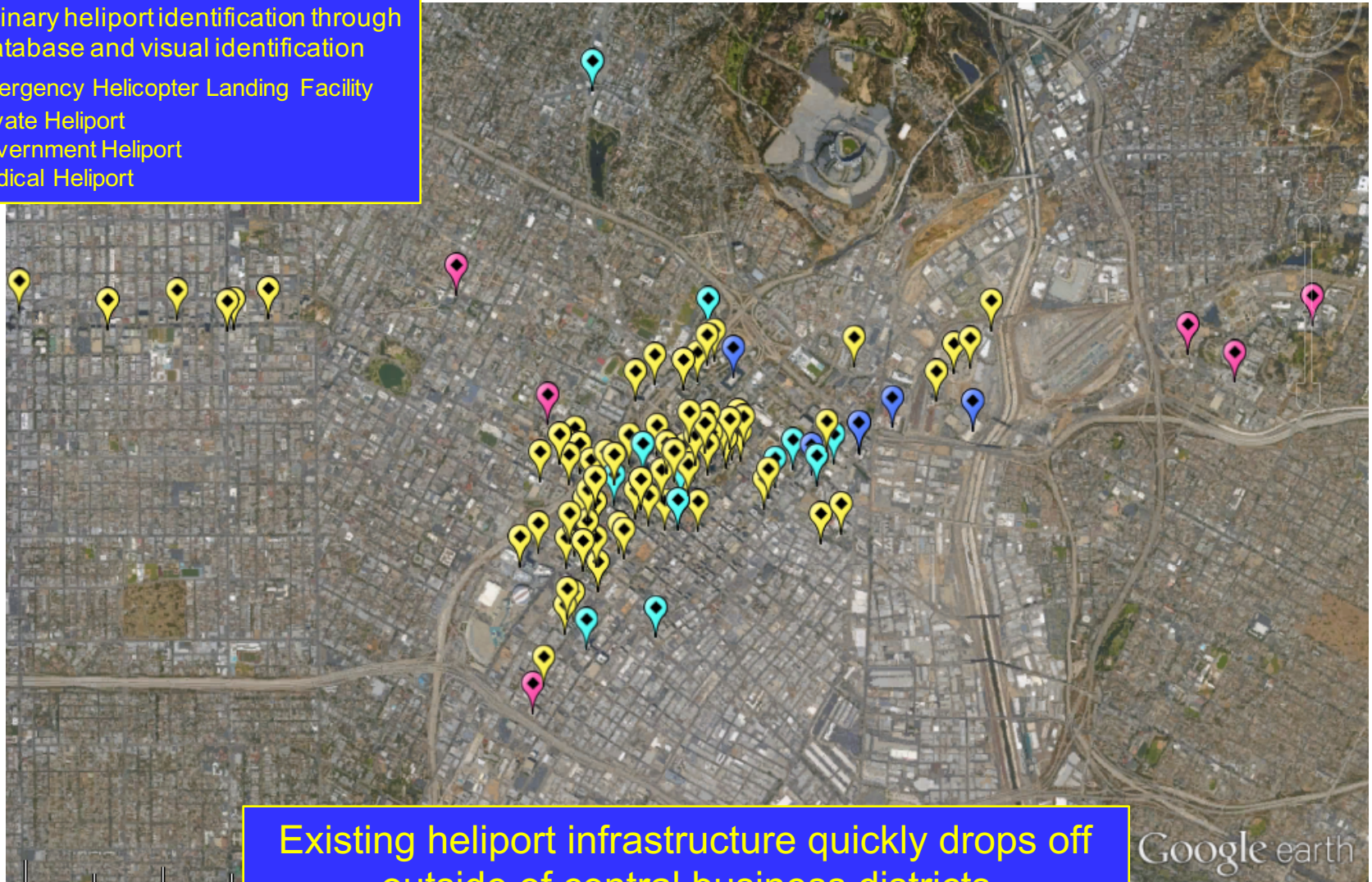


Central Business Districts have numerous private heliports and EHLFs

Existing LA Ground Infrastructure Constraints

Preliminary heliport identification through HAI database and visual identification

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Existing heliport infrastructure quickly drops off outside of central business districts

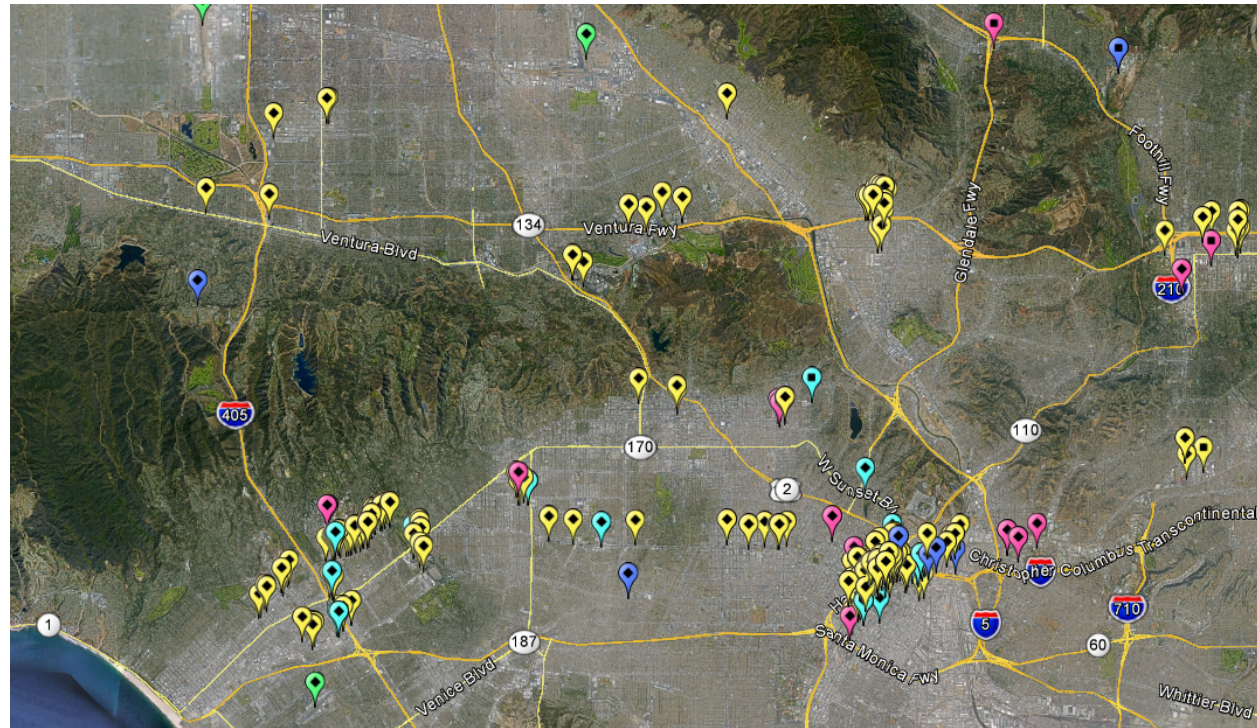
Google earth

Existing LA Ground Infrastructure Constraints

Preliminary heliport identification through HAI database and visual identification

-  Emergency Helicopter Landing Facility
-  Private Heliport
-  Government Heliport
-  Medical Heliport
-  Airport

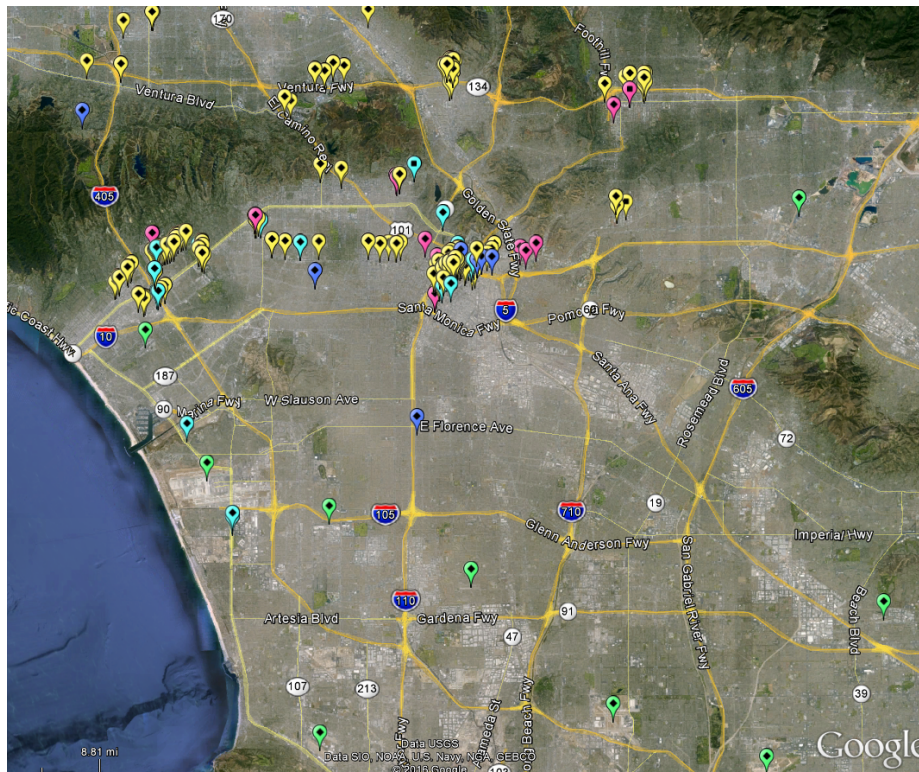
- Polycentric nature of Los Angeles is apparent through clumping of existing heliport infrastructure



- To support ODM, EHLFs must be updated and certified by the FAA for use beyond emergency situations
- Additional ODM landing facilities may be necessary to support operations outside central business districts

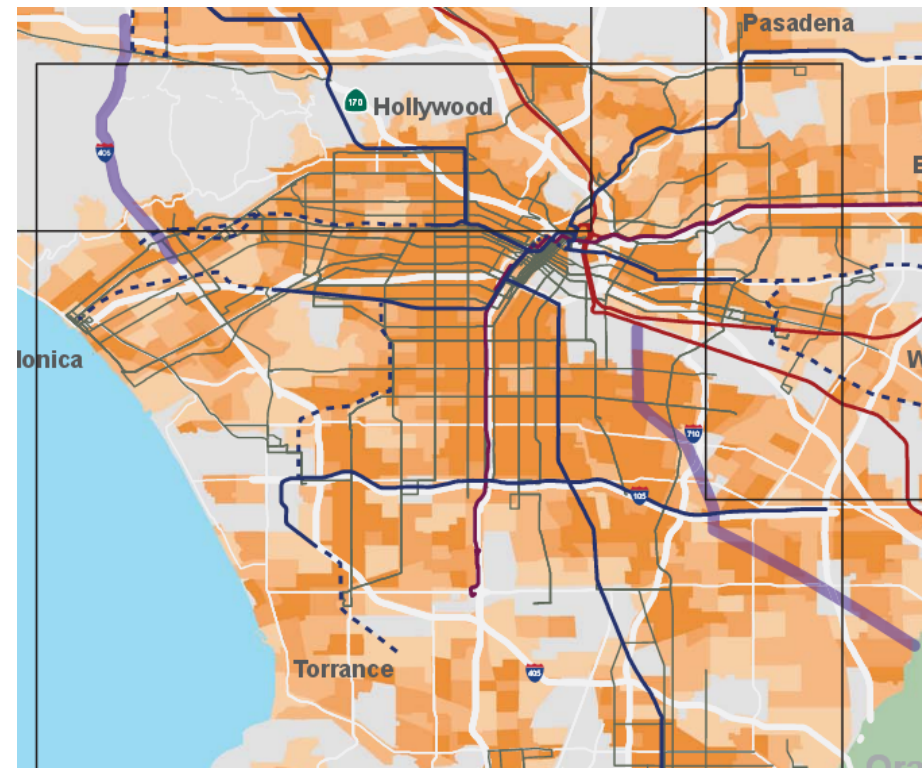
Existing LA Ground Infrastructure Constraints

Existing Helicopter Infrastructure



Google Earth

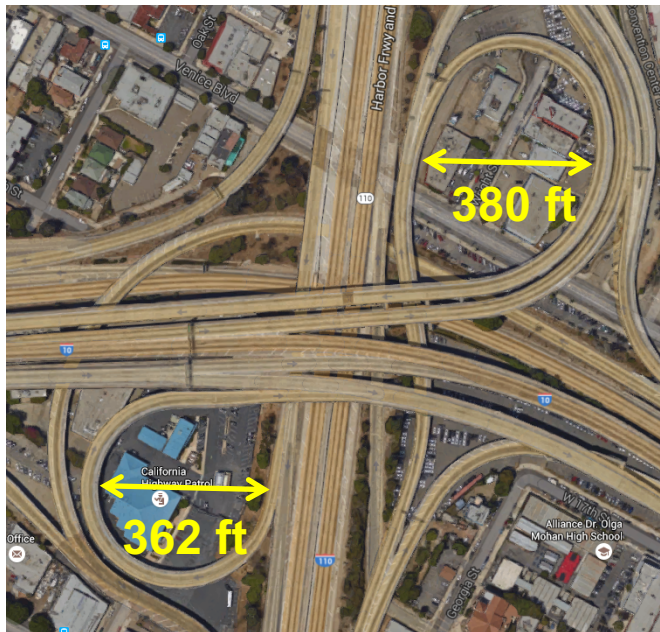
Population Density



reconnectingamerica.org

Existing LA Ground Infrastructure Constraints

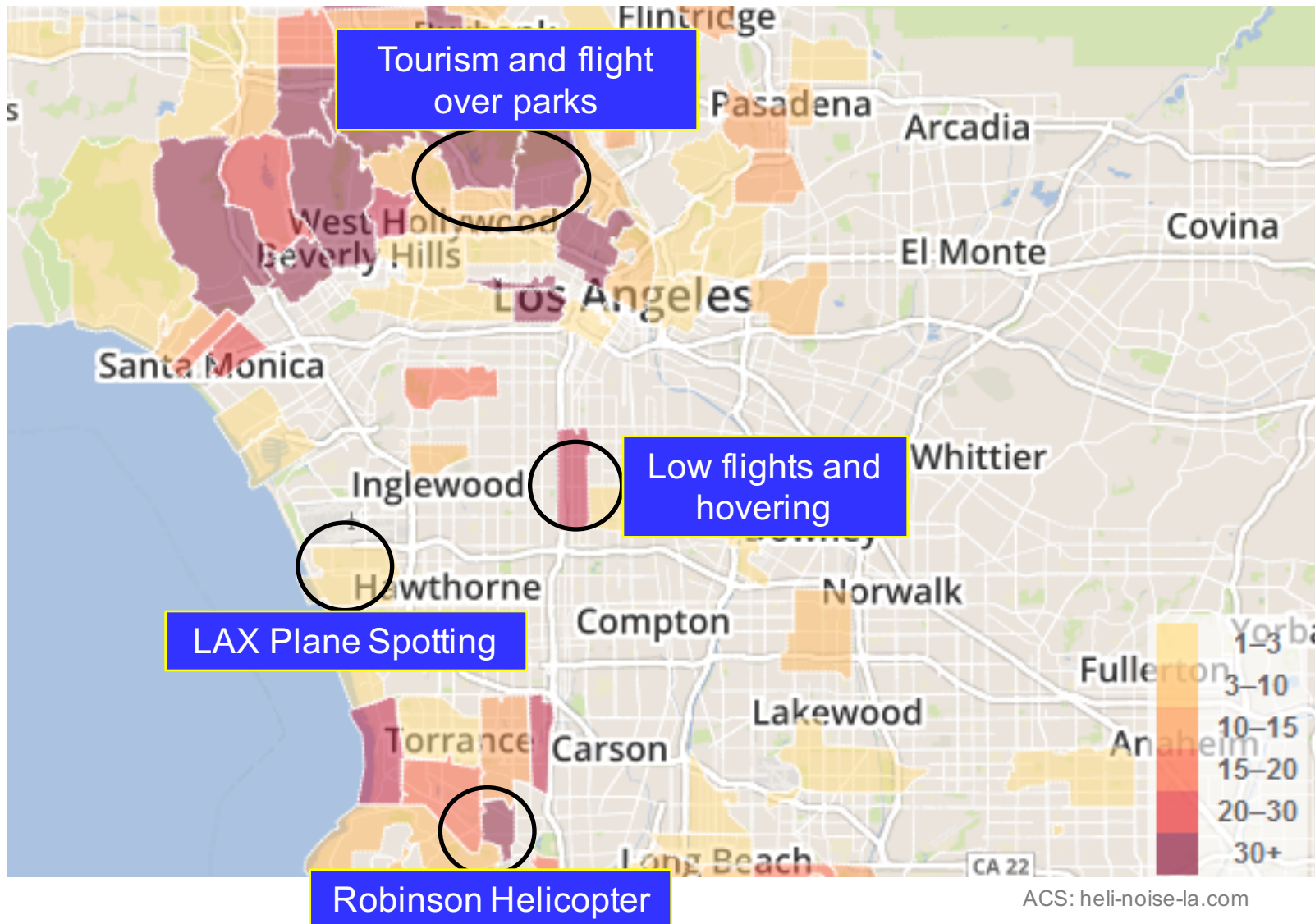
- **Developing vertiports in traffic interchange “clover leafs” has been proposed, as well as over interstates**
 - Land is generally already utilized in LA county if space is sufficient
 - Approach and departure path clearances and ground vehicle access requires further exploration



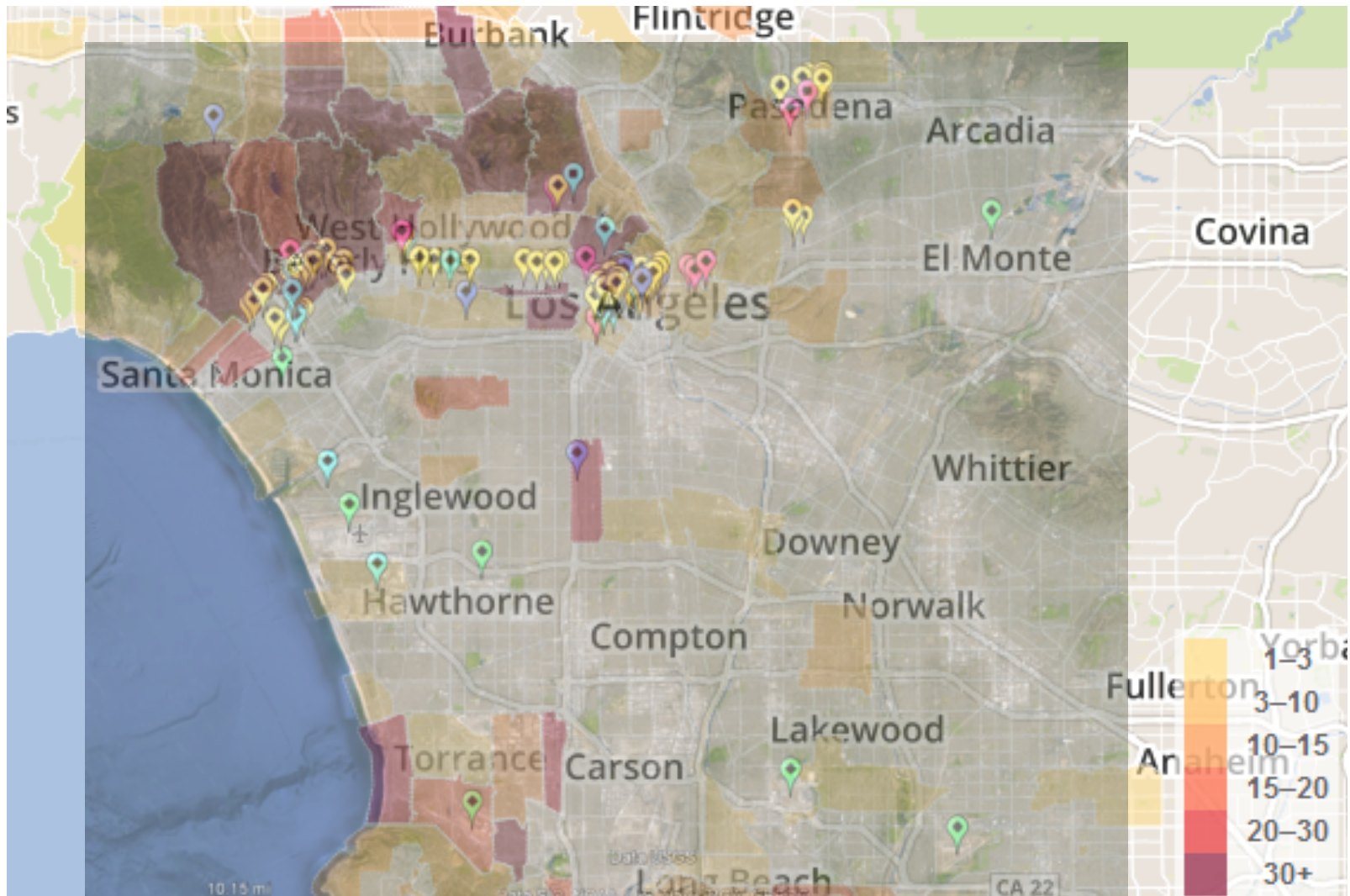
Noise Constraints

- **One of the most significant constraints for intra-city ODM operations will be noise**
- **The FAA has released multiple studies on the subject, including the 2013 *Los Angeles Helicopter Noise Initiative***
 - Identified noise “hot spots” in LA
 - Led to the development of three new helicopter routes
 - Created the LA Automated Complaint System (ACS) for noise
- **A majority of complaints originate from:**
 - Low altitude flights over neighborhoods
 - Extended hovering over tourist sites or news events
 - Flights over recreation areas and large, public events
 - The high concentration of flights near airports
 - Training and test flights near Robinson Helicopters

Noise Constraints



Noise Constraints





ODM Operations and Certification

- **A preliminary review of the Federal Aviation Regulations provides initial insights into potential ODM operation constraints**
 - § 91.117: Aircraft speed limitations
 - § 91.119: Minimum safe altitudes
 - Helicopters exempt if causing no hazard
 - § 91.151: Reserve fuel requirements for VFR conditions
 - § 93.95: Special air traffic rules for flight in vicinity of LAX
 - Basic VFR weather minimums in effect
 - Class B equipage required
 - Airspeed shall not exceed 140 knots
 - § 135.4: Pilot requirements for eligible on-demand operations
 - Must have a two-pilot crew
 - Pilots must have instrument ratings
 - § 135.203: VFR Minimum Altitudes

Summary

- **ODM aircraft intra-city operations present fundamentally new opportunities and challenges**
- **Our approach is to:**
 - Characterize potential missions based on consumer demand
 - Identify constraints from infrastructure, regulations, and operations, among others
 - Develop CONOPS for near-term and long-term operations

We welcome feedback from this group about our approach and their ideas for ODM CONOPS development



Thank You

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